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Students' pedagogical knowledge about teachers' use of questions

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High quality pedagogical knowledge is crucial for students, especially for teacher-education students, because it can assist them in their current learning and in helping their own future students' learning. This study of teacher-education students used a combination of qualitative and quantitative research methods to investigate three main research questions: (1) What pedagogical knowledge (SPK) do students have about teachers' use of questions? (2) How well-developed is this SPK? (3) Do students use this SPK in planning for teaching? The findings showed that students did have SPK about teachers' use of questions that involved a wide range of motivational, cognitive and metacognitive activities in teaching and learning. There was evidence that students did use their SPK in a simulated teaching situation. However, the extent of knowledge used depended on the situations students were involved in, on the types and the quality of the SPK, and on the availability of external probing.

Student pedagogical knowledge; teachers' use of questions; teacher-education students; knowledge of teaching; knowledge of learning

INTRODUCTION

The prior knowledge that students bring to the performance of any study task includes not only knowledge in subject-matter domains, but also knowledge in the domain of teaching and learning (Askell-Williams, 2004; Boulton-Lewis, 1992, 1994, 1998; Lawson & Askell-Williams, 2002). When students are involved in problem-solving tasks involving, say biology, they must use their knowledge of biology and their knowledge of how to acquire and manipulate that knowledge in order to solve the problems they are working on. If they are in a classroom their pedagogical knowledge will include knowledge of how to make effective use of what the teacher is saying or doing. Since instruction is an interactive process, students' knowledge of teaching and learning can play the role of mediator between the teachers' intentions, plans and actions and students' intentions, plans and actions (Askell-Williams, 2004). Because students need to manage their own learning much of the time, whether they are in a classroom or are undertaking independent study, they need to have knowledge of how to direct their own learning. In short they need to be able to teach themselves and so must call upon their own pedagogical knowledge. We refer to this knowledge as student pedagogical knowledge (SPK).

The recognition of students' knowledge of teaching and learning has been reported in studies on students' conceptions of teaching and learning (Meyer, Tabachnick, Hewson, Lemberger, & Park, 1999; Saljo, 1979), students' approach to learning (Biggs, 1987a, 1993; Marton & Saljo, 1976a, 1976b; Marton & Saljo, 1997), students' perceptions of teaching and learning (Entwistle, Skinner, Entwistle, & Orr, 2000; Elen & Lowyck, 1999; Winne and Marx, 1980, 1982) and on self-

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regulation and metacognition (Pressley, Van Etten, Yokoi, Freebern, & Van Meter, 1998; Winne & Hadwin, 1998; Zimmerman, 1995). More recently, more direct investigations of knowledge of teaching and learning has been discussed in the work of Elen and Lowyck (1999) and Lawson and his colleagues (Askell-Williams, 2004; Lawson & Askell-Williams, 2001; Lawson, Askell-Williams, & Murray-Harvey, 2002, 2003). These studies have found that knowledge of teaching and learning can vary widely between students.

In relation to students' knowledge about teachers' use of questions, Tran and Lawson (2003) found that this knowledge is quite similar in nature to teachers' pedagogical knowledge identified by Shulman (1987) in his analysis of the varieties of teachers' knowledge. In the Tran and Lawson study, participants' SPK was found to include a wide range of knowledge of motivational, cognitive and metacognitive activities of both teachers and students, with the most frequently accessed SPK being about cognitive activity.

Studies of student knowledge of teaching and learning have not only been concerned with the recognition of that knowledge, but also with the quality of that knowledge. Elen and Lowyck (1999) expressed their concern about the quality of their students' metacognitive instructional knowledge, as did Woolfolk-Hoy and Tschannen-Moran (1999, p.280-281) in a report on teacher education students in the United States:

> [prospective teachers] lack understanding of the connections between teaching strategies and students' learning … our students have great difficulty explaining the mechanism of learning and how teaching influences these processes …

Although there has been relatively little examination of the quality of SPK, there has been research on ways to think about knowledge quality. Different dimensions of quality of knowledge structures were identified by Mayer (1975) and White (1979). Descriptions of knowledge quality have been advanced in work by Biggs and Collis (1982), McKeown and Beck (1990), Hogan and colleagues (e.g Hogan, Nastasi, & Pressley, 1999) and Askell-Williams (2004). The Structure of Observed Learning Outcomes (SOLO) taxonomy developed by Biggs and Collis (1982) identified four dimensions of quality in learning outcomes: 1) capacity, which referred to working memory; 2) relating operation, which referred to the way in which an instructional cue and the student's response were interrelated; 3) consistency and closure in relating data and conclusions; and 4) structure, which represents the relations between cue, data and response(s). The SOLO taxonomy was used to assess quality of SPK in this project.

Although SPK has been described in some detail, the use of this knowledge has received less attention. The use of SPK has been explored in studies on the relationship between students' conceptions of teaching and learning and their classroom behaviours (Lemberger, Hewson & Park, 1999; Mellado, 1998; Meyer et al., 1999; and Wilson, Konopak & Readence, 1994), and between students' task perceptions and their planned and executed learning activities (Luyten, Lowyck & Tuerlinckx, 2001). A closer view to the use of knowledge of teaching and learning has been reported in Lonka, Joram and Bryson's (1996) study, in which students were expected to define the concept "learning" and to apply their definition to specify "the best way to enhance students' ability to learn", and explain their specification. Such research has not focussed on the use of knowledge held about teaching and its use.

The use of students' knowledge about teaching and learning is an issue of transfer of knowledge. Student teachers should be expected to use their knowledge of teaching and learning when they are doing their own learning and when they are teaching. It also seems reasonable to predict that the use of SPK would be related, in some degree, to the quality of that knowledge. Therefore, in the following studies we were interested to identify the range of student pedagogical knowledge accessed by the student-teacher participants and then to examine the extent of use of that knowledge and the relationship between knowledge quality and knowledge use.

METHOD: PARTICIPANTS AND PROCEDURE

Nineteen final year teacher-education students in an Australian university participated voluntarily in the study and were engaged individually in five sets of activities as summarized in Table 1. The group included students enrolled in junior primary/primary, middle school and secondary school programs. Upon acceptance of their participation, each student was advised of the time for their meeting with the researcher and was asked to bring to this meeting a sample of teaching materials involving a comprehension exercise that was typical of materials that would be used in their teaching practice situations. Reading passages used for the comprehension task in this interview were selected so that the material would be appropriate to the teaching field and interest of each participant. They were asked to ensure that the passage had at least five ideas that would form the subject of a lesson activity for a typical class that they would teach. Participants attended the research session individually and completed a questionnaire about teachers' use of questions and took part in two interviews.

Table 1: Procedures of the study

Sections	Participant activities
1. Introduction	Introduction
	Signing of consent form
	Check for comprehension task materials
2. Questionnaire	Completing the questionnaire
3. Training for think-aloud method	Reading the introduction,
	Listening to taped demonstration,
	Completion of practice tasks
4. Interview 1	Designing questions for teaching, using think aloud method
5. Interview 2	Choosing the most important question and explaining reasons for the choice

The questionnaire included an introduction section and six items. Each item was in the format of a free-response question, and consisted of a stem and two alternatives and space underneath for students to write their response. The introduction asked students to consider the two alternatives for each item and to select the one that they thought "would be the best for the teacher to do to help the student develop a good understanding" and then to explain the reason for their selection. Out of six questionnaire items, two were related to motivational functions, two to cognitive functions and the other two to metacognitive functions. The alternatives used in the questionnaire were adapted from recent inventories of motivational, cognitive and metacognitive aspects of teaching and learning such as R-SPQ-2F (Biggs 1987b; Biggs, Kember & Leung 2001), MSLQ (Pintrich, Smith, Garcia & McKeachie, 1991), MSLQ-CV (Rao, Moely & Sachs, 2000), LASSI (Weinstein, 1987), and MAI (Schraw & Dennison, 1994).

Following completion of the questionnaire students were trained in the use of a think-aloud procedure, using procedures adapted from Ericsson and Simon (1993). Each student then participated in two interviews focussed on the teaching materials that he/she had selected for this activity. In Interview 1 students were asked to think aloud as they designed questions for their comprehension teaching task, questions that would assist their students to comprehend the ideas in the passage. Following completion of this activity, in Interview 2, students were asked to select one of their designed questions that they thought the most important to ask in terms of helping students understand the comprehension task material. They were asked to explain the reason for their selection. Probing questions were asked to help them expand, clarify and interpret their ideas. The students' responses in both interviews were recorded and transcribed for analysis.

Student responses to the questionnaire and the talks in two interviews were analyzed in similar ways. They were read and reread to detect relevant issues, which were then classified into six categories of knowledge: Motivational knowledge in teaching, Motivational knowledge in learning, Cognitive knowledge in teaching, Cognitive knowledge in learning, Metacognitive knowledge in teaching and Metacognitive knowledge in learning. The number of relevant issues was counted for each knowledge category and for each situation. The results of this descriptive analysis are reported first in the Results section.

The main purpose of the following analyses was to investigate the relationships between the SPK accessed by students in the questionnaire and the subsequent use of that knowledge in the interview sessions that involved a simulation of planning for teaching. In order to do that, students' responses to the Questionnaire and talks in Interview 1 and Interview 2 were analyzed using four dimensions proposed for assessing the quality of SPK: the extent of knowledge; the specificity of knowledge, which is a measure of the technical vocabulary associated with teaching and learning processes; the degree of elaboration of within-schema connections; and the quality of between-schema connections, as measured by the capacity and relating operation dimensions of the SOLO taxonomy (Biggs & Collis, 1982).

Correspondingly, four measures of students' SPK accessed in the interview were developed: (1) Issues, which indicated the number of issues mentioned that were relevant to teaching and learning; (2) Specificity, indicated by the number of general terms used (Spec 1) and the number of more specific terms used (Spec 2); (3) Elaboration (Elab), as indicated by the degree of the expansion students made about a relevant issue; and (4) SOLO ratings of the extent to which separate issues relevant to teaching and learning were inter-related. In the following section, each of these measures is accompanied with a subscript of "h" which refers to the fact that they are measures of knowledge *held* by students, as indicated by questionnaire responses.

Knowledge *used* by students in the interview sessions was assessed in terms of SOLO score and number of issues mentioned. Therefore, there are two measures of knowledge use for each interview situation: SOLO score in Interview 1 (Solo1); number of issues in Interview 1 (Issue1), SOLO score in Interview 2 (Solo2) and number of issues in Interview 2 (Issue2). Each of these four measures is accompanied with the subscript "u" referring to measures of knowledge used by students as they developed questions for use in teaching in the interviews. The reliability and validity of these measures were examined and measurement methods gave evidence that both were acceptable (see Tran, 2006).

RESULTS

Knowledge accessed in Questionnaire, Interview 1 and Interview 2

This first set of findings focuses on the number of issues that students, as a group, reported on the three different tasks they undertook in the study. Table 2 is a summary of the frequency of knowledge issues reported by the group of students in each of the six knowledge categories, and the number of students who represented that category in each situation.

Table 2: The number of issues and students (n) represented in each situation

	Questionnaire		**Interview 1**		**Interview 2**	
	Issue	n	Issue	n	Issue	n
Motivational knowledge in teaching	7	8	4	4	9	11
Motivational knowledge in learning	13	14	7	7	7	8
Total for motivational knowledge	20	18	11	9	16	13
%	31.7		22.9		28.6	
Cognitive knowledge in teaching	8	13	8	6	8	16
Cognitive knowledge in learning	22	19	22	19	23	19
Total for cognitive knowledge	30	19	30	19	31	19
%	47.6		62.6		55.3	
Metacognitive knowledge in teaching	5	17	5	12	5	13
Metacognitive knowledge in learning	8	12	2	3	4	8
Total for metacognitive knowledge	13	18	7	12	9	15
%	20.6		14.5		16.1	
Total issues on each occasion	63		48		56	

As can be seen from the table, the profiles of knowledge use of students as a group were different in the three situations. They used relatively more knowledge in general in the Questionnaire and Interview 2 situations than in Interview 1, and used more motivational knowledge and metacognitive knowledge in the Questionnaire than in Interview 1 or Interview 2. Cognitive

knowledge in learning was the dominant focus of students' knowledge about teachers' use of questions in each situation: ($\chi^2_Q(2) = 6.95$, $p < 0.05$; $\chi^2_{I1}(2) = 18.88$, $p < 0.001$; $\chi^2_{I2}(2) = 13.54$, $p < 0.01$) and this focus was strongest when students worked on their own without receiving any cues or external probing in the Interview 1 situation.

Although nearly all students reported some use of motivational, cognitive and metacognitive knowledge in the Questionnaire situation, some students did not use any motivational and metacognitive knowledge in Interview 1 and Interview 2 situations. In Interview 1, eleven of the 19 students did not report any use of motivational knowledge, and six did not report motivational knowledge in Interview 2. Five students did not use metacognitive knowledge in Interview 1, and four did not use metacognitive knowledge in Interview 2. Furthermore, the number of issues individual students reported for motivational and metacognitive issues was lower than the number of cognitive issues, especially in Interview 1 as shown in Table 3.

Table 3: Mean and range of the number of issues in knowledge categories in three situations

	N	Range	Mean	SD
Questionnaire situation				
Motivational knowledge	19	0-6	2.68	1.70
Cognitive knowledge	19	1-7	3.84	1.95
Metacognitive knowledge	19	1-4	2.47	1.12
Interview 1 situation				
Motivational knowledge	19	0-4	0.84	1.21
Cognitive knowledge	19	1-8	3.84	1.89
Metacognitive knowledge	19	0-5	1.21	1.23
Interview 2 situation				
Motivational knowledge	19	0-4	1.58	1.43
Cognitive knowledge	19	3-11	6.63	2.14
Metacognitive knowledge	19	0-6	2.26	1.76

In comparing the number of motivational, cognitive and metacognitive issues mentioned by each student in the three situations, as shown in Table 4, paired sample t-tests showed that students used significantly more motivational knowledge in the Questionnaire than in Interview 1 and Interview 2 situation. This result might be associated with the cues provided for motivational knowledge in the Questionnaire situation. With regard to metacognitive knowledge, students used it more in the Questionnaire situation than in Interview 1, but the means for Questionnaire and Interview 2 were not significantly different. External prompts in the Interview 2 situation could have enhanced the accessibility and use of metacognitive knowledge in that situation. However, the effects of external prompts could be seen more clearly in the case of the use of cognitive knowledge when students used more of this knowledge in Interview 2 than in the Questionnaire and Interview 1 situations.

Table 4: Results of paired sample t-tests for knowledge categories across the three situations

		t	df	Sig. (2-tailed)
Pair 1	Q motivation - Int1 motivation	4.53	18	0.00
Pair 2	Int1 motivation - Int2 motivation	-1.71	18	0.11
Pair 3	Q motivation - Int2 motivation	2.45	18	0.03
Pair 4	Q cognitive - Int1 cognitive	0.00	18	1.00
Pair 5	Int1 cognitive - Int2 cognitive	-4.85	18	0.00
Pair 6	Q cognitive - Int2 cognitive	-5.73	18	0.00
Pair 7	Q metacognitive - Int1 metacognitive	2.76	18	0.01
Pair 8	Int1 metacognitive - Int2 metacognitive	-2.11	18	0.049
Pair 9	Q metacognitive - Int2 metacognitive	0.40	18	0.69

Note: Q = Questionnaire; Int1 = Interview 1; Int2 = Interview 2

When knowledge use across situations was examined, only 11 of the total 85 issues reported in the study were used across all three situations, most of these issues (7/11) referring to cognitive activity. This pattern of knowledge use was evident in the responses of 13/19 students. Students not only used less knowledge related to motivational and metacognitive issues, but also did not

mention the learner's role in generating motivational and metacognitive activities, nor the effect those activities have on teachers or teaching. Regardless of the type of knowledge, most issues reported across all three situations were related to general rather than specific activities. For example, students reported such general activities as thinking, remembering, applying, evaluating but did not mention specific strategies for learning from teacher questions. The use of specific strategies might indicate a higher level of quality of student knowledge. The lack of specific strategies in this group suggests a low level of quality of the used knowledge.

Being used consistently across the three situations, this knowledge appears to be most accessible for students and could be argued to be the strongest or most activated knowledge. Therefore, the limited range and amount of such knowledge is of concern. Since teacher questioning is a frequent teaching activity, students, and teacher-education students in particular, are expected to use their knowledge about teachers' use of questions frequently. However, as indicated in the results, their knowledge about teachers' use of questions seems to be not strong enough to be accessed and used whenever it is needed. Moreover, while the accessibility and usage of this knowledge is very much dependent on the situation, in reality students are expected to use the knowledge in many situations that do not facilitate such use, because they are often teaching on their own. Consequently, it is likely to be difficult for such teacher education students to make use of their knowledge in such a situation.

By way of contrast there was a greater frequency of issues that were reported in only one of the study situations. For example 52/85 issues were reported by students only in the Questionnaire and this pattern of use involved all 19 students. Again, most (42.3%) of these issues referred to cognitive activity, with lower frequencies for motivational (34.6%) and metacognitive (23.1%) activity.

The profile of knowledge used in the Questionnaire and Interview 1 was very similar to that associated with consistent knowledge use in all three situations. The number of issues reported in these two situations was relatively small (9/85) with this pattern being evident in 8/19 students. With regard to the content of knowledge in this group, more than half of the issues in this group were related to the cognitive category of knowledge, and was general rather than specific.

These results indicate that the knowledge activated by the Questionnaire and used spontaneously for designing questions for teaching was quite limited. It was not only limited in amount but also in the range of content. The knowledge content focused on cognitive knowledge in learning and did not involve the active role of students in motivational and metacognitive activities. As this knowledge is argued to be representative of that which would be accessed and used in the actual teaching situation, the limited extent and range of knowledge content of this knowledge use in this study suggests that these students might not use much of their SPK about teachers' use of questions in their planning for teaching.

The number of issues reported in both the Questionnaire and Interview 2 situations was larger. Twenty six issues were reported in both situations, with 16 students showing this pattern. The issues covered all six categories of knowledge and included more specific procedures than that in the previous pattern. Cognitive knowledge was the most frequent (57.7%) and students referred to more specific cognitive procedures, such as analysing, linking parts in a lesson, and reflection.

The difference in knowledge accessed in the Questionnaire and reported in the two Interview situations can be argued to be associated with the difference in the conditions of these situations. The requirement for explanation in response to the interviewer's probing questions in Interview 2 seemed to facilitate the accessing of knowledge, especially knowledge about motivational and metacognitive activities. Therefore, it might be predicted that students would use more such knowledge in planning for teaching if they received some external prompts. The report of more specific learning activities in Interview 2, may indicate that more specific learning activities are more likely to be accessed and used in situations with external prompts rather than without them.

The remaining pattern of knowledge use involved issues that were reported only in the two interview situations. Although 22/85 issues were reported in these situations, with 14 of the students showing such a pattern of knowledge use, the issues reported were predominantly to do with cognitive activity (81.9%). Only one issue belonged to motivational knowledge and three issues to metacognitive knowledge. The descriptions of cognitive activities included more specific procedures such as imagining, highlighting, visualizing, analyzing, comparing, explaining and linking to issues outside of lesson content. The knowledge accessed in these situations was activated by the process of designing questions and reasoning about the best designed question. So the teaching task and the content of the reading material could have facilitated knowledge activation and the requirement to explain the most important question and the interview probing questions could maintain it. Knowledge in this group is of interest because as it was activated spontaneously in Interview 1 (without probes) and used again in the Interview 2 situation, and so appears to be relatively highly accessible for students in teaching situations.

It appears that when specific cues for motivational and metacognitive knowledge were not provided, as in Interview 1 and Interview 2 situations, cognitive knowledge was accessible for students, but motivational and metacognitive knowledge was less accessible. The result again suggests that in order to facilitate the activation and use of motivational and metacognitive knowledge in actual teaching situations, specific cues for those kinds of knowledge would need to be provided for many students. In situations where specific cues for motivational and metacognitive knowledge are not provided, the student teachers in this study used mainly cognitive knowledge.

Path analysis

In order to examine relationships between indicators of student knowledge held and the measures of the use of that knowledge, path models that represented those relationships were built and tested. Each path model included three latent variables, two of these being explanatory variables from indicators of student knowledge and the other variable being one of the criterion measures of knowledge used by students. An example of a path models is shown in Figure 1.

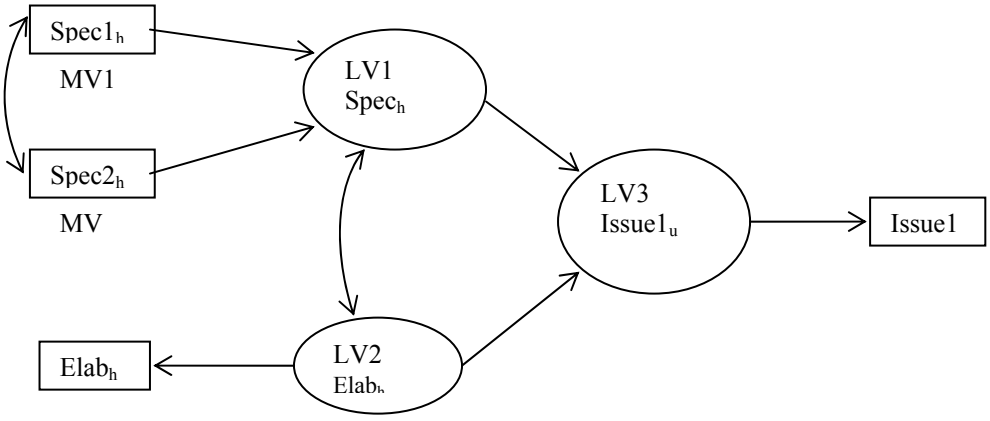

Figure 1: Path model to test Propositions

In this figure, rectangles represent manifest or observed variables while ellipses indicate latent variables. A unidirectional arrow from one variable to another represents a causal relationship from the determining variable to the variable dependent on it. A bidirectional curved arrow indicates a noncausal correlation between variables in the model.

PLSPATH (Sellin, 1989; 1990) (version 3. 01) was used to test the models. Table 5 presents in summary form the regression coefficients between the latent variables that are shown in Figure 1, where $Issue1_u$ is regressed on the two regressors $Spec_h$ and $Elab_h$.

In the path model, $Spec1_h$ and $Spec2_h$ are combined to form a new latent variable called Specificity ($Spec_h$). As these two observed variables represent the same component of student

knowledge, the precision of knowledge, and are highly correlated with each other (r=0.55), their combination simplifies the analysis and provides a clearer understanding of the relationships under examination. In forming $Spec_h$, $Spec2_h$ contributes more than $Spec1_h$ with the weights being 0.75 and 0.37, respectively. This indicates that the holding of specific terms as assessed by $Spec2_h$, has a greater influence on forming Specificity ($Spec_h$) than $Spec1_h$.

Table 5: Regression coefficients between latent variables

	$Issue1_u$	$Issue2_u$	$Solo1_u$	$Solo2_u$
$Issue_h$	0.13	0.08	-0.04	**0.55***
$Spec_h$	-0.01	0.25	0.28	-0.10
$Issue_h$	**0.66***	0.36	-0.14	-0.03
$Elab_h$	*-0.66**	-0.06	0.37	**0.58***
$Issue_h$	**0.60***	-0.15	0.07	-0.18
$Solo_h$	*-0.64**	**0.58***	0.14	**0.81***
$Spec_h$	**0.65***	0.20	0.16	*-0.50**
$Elab_h$	*-0.63**	0.08	0.11	**0.98***
$Spec_h$	**0.40†**	-0.05	0.22	-0.21
$Solo_h$	*-0.42†*	**0.49***	0.05	**0.81***
$Elab_h$	0.20	*-0.53**	0.31	-0.08
$Solo_h$	-0.33	**0.91***	-0.06	**0.74***

†: $\alpha < 0.10$ (n=19); *: $\alpha < 0.05$ (n=19)
Numbers in bold: Correlations are positive and significant
Number in Italic: Correlations are negative and significant

In all, 24 simple trivariate regression models were analysed, there being six pairs of regressors formed for the four regressor explanatory variables (the held variables) and the four criterion measures (the used variables). A summary of the path coefficients between variables is shown in Table 5. Each row involves two predictor variables and their path coefficients, with one serving as an indicator of knowledge used in either Interview 1 or Interview 2. The discussion of results focuses only on path coefficients that are significant at least at the 10% level.

The relationship between the amount of knowledge held and the amount of knowledge used

This analysis focussed on the quantity of knowledge held in the Questionnaire situation and knowledge used in the interviews. As can be seen from Table 5, when controlled for $Elab_h$ or $Solo_h$, respectively, the path coefficients (standardized regression effects) between the number of issues raised in the Questionnaire ($Issue_h$) and the number of issues raised in Situation 1 ($Issue1_u$) were high, positive and significant (at 5% level) of 0.66 and 0.60 for $Elab_h$ and $Solo_h$. Thus when the effects of the nature of student knowledge, as indicated by the degree of within- or between-schema correlations, were used to statistically control the amount of knowledge held by students, the amount of knowledge held was strongly related to the amount of knowledge students used in the unprompted situation. More simply stated, for those students who had the same level of degree of within- or between-connections, the more knowledge they possessed, the more knowledge they used when they were in the unprompted situation of planning for teaching in Interview 1.

In contrast to Interview 1, there are no similar effects of the amount of knowledge held on the amount of knowledge used, in Interview 2 when controlled for either $Elab_h$, $Solo_h$, or $Spec_h$ the amount of knowledge used by students in the prompted situation was influenced by other factors but not by the amount of knowledge that they held.

The relationship between the amount of knowledge held and the nature of knowledge used

In this analysis the relationships of interest are between the indicator of knowledge reported in the Questionnaire and the SOLO ratings of knowledge used in the two interview situations. As shown in Table 5, $Issue_h$ did not significantly influence $Solo1_u$ when controlled for $Spec_h$, or $Solo_h$, or

$Elab_h$, but did influence $Solo2_u$ significantly when controlled for $Spec_h$, with the path coefficient of 0.55. The results indicate that, when controlled for the level of Specificity, the greater the amount of knowledge held the higher the level of between-schema connections in the prompted Interview 2 situation.

The relationships between the nature of knowledge held and the amount of knowledge used

The relationships of interest in this analysis were between the qualitative measures of knowledge held and the amount of knowledge used subsequently in the two interview situations. Similar to $Issue_h$, $Spec_h$ influenced the number of issues raised in Interview 1 ($Issue1_u$) strongly when controlled for $Elab_h$ (with beta=0.65, significant at the 5% level) and moderately when controlled for $Solo_h$ (with beta=0.40, significant at the 10% level). The results suggested that after controlling for the degree of elaboration of student knowledge, as indicated by the degree of within- and between-schema connections, the level of precision of that knowledge was related to the amount of knowledge used by students when they planned teaching on their own. In other words, at a constant level of within- or between-schema connections, the higher the level of the precision of knowledge the students possessed, the more knowledge they used when they were in the unprompted situation of planning for teaching.

The effects of $Solo_h$ and $Elab_h$ on the number of issues raised by students in Interview 1 are opposite to the effects of $Issue_h$ and $Spec_h$ as mentioned previously. When controlled for $Issue_h$ or $Spec_h$, $Elab_h$ and $Solo_h$ are negatively related to $Issue1_u$. Thus the degree of within- or between-schema connections held by students negatively and significantly influenced the number of issues raised by students when they planned teaching on their own. In situations where students had control of the accessibility of their knowledge, it seems that the activity involved in generating within- or between-schema connections might restrict them from raising more issues. Thus, at the same level of specificity or the same amount of knowledge held, the higher the degree of within- or between-schema connections held, and the less knowledge they accessed and used without assistance.

In comparison with Interview 1, the effects of all three explanatory variables $Spec_h$, $Solo_h$ and $Elab_h$ on the number of issues raised in Interview 2 were very different. Among them, only $Solo_h$ was positively and significantly related to $Issue2_u$ when controlled for $Issue_h$, $Spec_h$ or $Elab_h$. $Solo_h$ strongly influenced $Issue2_u$ with the path coefficient of 0.58 when controlled for $Issue_h$. This result indicated that after controlling for the number of issues mentioned in the Questionnaire, the degree of between-schema connections held by students strongly influenced the number of issues raised in the situation where they were prompted by the researcher. In other words, for students who held the same amount of knowledge, the higher the level of between-schema connections, the more knowledge they used in the prompted situation. Similarly, $Solo_h$ influenced $Issue2_u$ moderately with a path coefficient of 0.49 when controlled for $Spec_h$, and very strongly with a path coefficient of 0.91 when controlled for $Elab_h$. Thus, at the constant level of specificity, or the same level of within-schema connections held, the higher the level of between-schema connections, the more knowledge they used when prompted.

When controlled for $Solo_h$, $Elab_h$ is negatively related to $Issue2_u$ with a path coefficient of -0.53. Thus the degree of within-schema connections held by students restricts the number of issues raised when students are prompted by the researcher in their planning for teaching. At the same level of between-schema connections held, the higher the degree of within-schema connections held, the less knowledge students used when they were in the prompted situation of planning.

The relationships between the nature of knowledge held and the nature of knowledge used

There are no significant effects of either $Spec_h$, $Solo_h$, or $Elab_h$ on $Solo1_u$ under any conditions of statistical control. The result indicates that in Interview 1 the nature of knowledge students used, as assessed by the between-schema connections, in the situation where they planned teaching on their own did not depend on any of the indicators of quality of knowledge that they held.

In contrast to Interview 1, the nature of knowledge used by students in Interview 2 depended heavily on the nature of knowledge held. The analysis showed high to very high path coefficients between $Spec_h$, $Elab_h$, and $Solo_h$ explanatory variables and the criterion variable $Solo2_u$. More specifically, $Elab_h$ is positively and strongly related to $Solo2_u$ when controlled for $Issue_h$ (beta=0.58) and very strongly related when controlled for $Spec_h$ (beta=0.98). Similarly, $Solo_h$ is positively and strongly related to $Solo2_u$ when controlled for $Issue_h$ (beta=0.81), for $Spec_h$ (beta=0.81), or for $Elab_h$ (beta=0.74). $Spec_h$, in contrast, is strongly but negatively related to $Solo2_u$ when controlled for $Elab_h$ (beta=-0.50). These results indicate that the quality of the knowledge held by students influenced the quality of the knowledge used when they were prompted in planning for teaching. The higher the level of knowledge held, as assessed by the level of within- or between-schema connections, the more developed was the knowledge they used in the prompted situation. However, at a constant level of within-schema connections, the higher the level of the precision of knowledge held, the lower the level of between-schema connections.

Summary of Path Analyses

A summary of the interpretations of the results obtained from the path analysis is given in Table 6. The amount of knowledge held influenced the amount of knowledge used in an unprompted, but not in a prompted situation. The degree of development of knowledge held influenced the amount of knowledge used in both unprompted and prompted situations, except for the effect of the characteristic of the degree of development that was assessed by the specificity of terms held on the amount of knowledge used in the prompted situation. The amount of knowledge held influenced the degree of development of knowledge used in the prompted situation, but not in the unprompted one. And finally, the degree of development of knowledge held influenced the degree of development of knowledge used in the prompted but not in the unprompted situation.

Table 6: Summary of the effects of knowledge held on knowledge used in trivariate regression analysis

	Amount of knowledge used in:		The degree of development of knowledge used in:	
	Situation 1	Situation 2	Situation 1	Situation 2
Amount of knowledge held	Yes	No	No	Yes
The degree of development of knowledge held				
- Precision	Yes	No	No	Yes
- Within-schema connections	Yes	Yes	No	Yes
- Between-schema connections	Yes	Yes	No	Yes

The results obtained from the path analysis show a clear picture about how differently knowledge held influences knowledge used in the unprompted and prompted situations. In the most general view, the amount of knowledge used in the unprompted situation was influenced more by the knowledge students held than was the amount of knowledge used in the prompted situation. Eight out of 12 coefficients that represent the relationships between knowledge held and amount of knowledge used in Interview 1 are significant, while only four coefficients out of 12 that represent the relationships between knowledge held and amount of knowledge used in Interview 2 are significant. Furthermore, the differences are not only in the size of coefficients but also in their sign. For example, when controlled for $Issue_h$, $Solo_h$ negatively influences $Issue1_u$, but is positively related to $Issue2_u$.

The differences between two situations are more obvious in the effects of knowledge held on the degree of development of knowledge used. The path analysis does not show any evidence for the relationship that knowledge held influences significantly the degree of development of knowledge used when students planned for teaching on their own. On the contrary, after controlling for the effects of certain explanatory variables, all characteristics of knowledge held significantly influence the degree of development of knowledge used in the prompted situation.

DISCUSSION

The descriptive analysis of data showed that Australian teacher-education students do have knowledge about teachers' use of questions, as part of their pedagogical knowledge. The knowledge about teachers' use of questions involves motivational, cognitive and metacognitive knowledge of teaching and learning activities. In this general sense, the results obtained from this study coincide with the findings with Vietnamese teacher-education students in Tran and Lawson's work (2003).

Results from the studies showed that students could use their knowledge about teachers' use of questions for explaining the effectiveness of teacher questions in the Questionnaire situation, for designing questions for teaching a comprehension task and for reasoning about the most important question. This knowledge use was associated with the types of knowledge, the quality of knowledge and the conditions of the situations in which students were expected to use it.

The use of student knowledge about teachers' use of questions was, however, focused on cognitive knowledge rather than on motivational or metacognitive knowledge. Students used cognitive knowledge, especially cognitive knowledge in learning, without any kind of external support. It seems that students have more cognitive knowledge than motivational and metacognitive knowledge and their cognitive knowledge is also stronger and more accessible than their motivational and metacognitive knowledge. Therefore, as training courses aim to equip students with knowledge of teaching and learning, they should also focus on motivational and metacognitive knowledge. Despite the emphasis on students' active role in teaching and learning activities in contemporary teaching and learning theories, the student knowledge use about teachers' use of questions shows little evidence of this. The lack of student activity is especially noticeable in the case of motivation. The finding is of particular concern when participants in this study are prospective teachers.

With regard to the relationships between knowledge use and the quality of knowledge, the results from the study showed that the effect of the amount and the degree of development of knowledge held on the amount and the degree of development of knowledge used varied between situations. By showing the effects of the amount of knowledge held by students ($Issue_h$) on the amount and degree of development of knowledge used, the results indicate the important role of the amount of knowledge held by students. Although it is less the focus of educators, it can be an important indicator of teacher- education students' learning when it is shown to contribute to the prediction of the knowledge the students use when planning their lessons.

Moreover, because a high level of precision (Specificity) can enhance the use of more knowledge when students work on their own to plan for teaching, this component is an important requirement of effective planning. However, there is reason to be concerned about the precision of student knowledge. While the results of this study show that more specific terms contributed more to the precision of student knowledge than general terms in the practical situation, students are said to have a lack of a specific or technical vocabulary (Askell-Williams, 2004; Elen & Lowyck, 1999; Lawson & Askell-Williams, 2004). This lack of technical vocabulary, or lack of more specific terms, may constrain students in using large amounts of the knowledge that they hold. Therefore, an increase in the size of the technical vocabulary of these teachers should be an issue of concern in program planning.

With regard to the effects of the context of knowledge use, both descriptive and statistical analysis showed the relationships between knowledge use and the conditions of interview situations in which students were expected to use their knowledge. The variety of the patterns of student knowledge use in the different situations indicates that knowledge use is very situated. Students activated and used more extensive knowledge, including more motivational and metacognitive knowledge in the Questionnaire situation, where they received both external cues and were required to give explanations, than in the Interview situations. Students used more knowledge about more specific activities when they were prompted to activate more knowledge in Interview 2. The situatedness of knowledge use is supported by the observation that not much of the same knowledge is used across the three different situations. In this study some knowledge could be accessed and used in only one situation. Knowledge accessibility and use appear to be associated with the situation students are in and its conditions and features.

The relationships between the knowledge held by students and the knowledge used by them differed when students planned for teaching on their own and when they were prompted by the researcher. When students planned for teaching on their own, the amount of knowledge used strongly depended on their capability to express relevant ideas precisely and the amount of knowledge they held, while the amount of knowledge used was constrained by the students' capability of creating connections within- or between schemas. On the contrary, the degree of development of knowledge used in this situation was independent of the amount and the degree of development of knowledge that the students held. When students planned for teaching with external guidance, both the amount and the degree of development of knowledge used in this situation depended strongly on the indicators of knowledge held by students.

The situatedness of knowledge use seems to link to the situated nature of learning and student knowledge, as argued by representatives of situative theory such as Greeno (1997; 1998). In each situation students have to be attuned to particular constraints and affordances, which require them to activate and use different knowledge. The situated nature of knowledge, on the other hand, constrains transfer to, or the use of knowledge in other situations (Bereiter, 1995; 1997) and this was the reason for the limited amount and type of knowledge that is used across situations. As argued by Bereiter (1997) if students cannot overcome the situatedness of knowledge, their use of knowledge is problematic. When knowledge is strongly bonded to a specific situation, and students cannot break this bond, they can transfer or use it only in that situation or in situations where their constraints and affordances are similar to those of that situation. The results here support Bereiter's analysis. Many students could not break the situatedness of their SPK enough to use their SPK in the three different situations they experienced in this study.

Another possible explanation for the difference of the patterns of student knowledge use obtained from this study is associated with the issue of spontaneous transfer. Students used relatively little of their knowledge about teachers' use of questions spontaneously in the Interview 1 situation. Since the spontaneous use of knowledge is argued to be related to the depth of knowledge (Hiebert & Wearne, 1988), and students' ability (Campione & Brown, 1984), this limited spontaneous use is of concern for teacher educators. It seems that teacher-education students in this study have only a limited amount of knowledge about teachers' use of questions which is strong and accessible enough to be used spontaneously in planning for teaching.

The lack of spontaneous use of knowledge is especially obvious in the case of motivational and metacognitive knowledge and of knowledge about more specific activities. The results indicate the weak points in student knowledge in those types of knowledge and suggest implications for teacher educators. Because spontaneous use of SPK is limited, and external support can facilitate such knowledge use, as shown in the pattern of responses in the Questionnaire and Interview 2 situations, some kinds of prompts may need to be provided to student teachers and novice teachers when they plan for teaching. The external support could be in the form of specific cues, especially for motivational and metacognitive knowledge. Such external supports would encourage students to activate more knowledge about teaching and learning.

As planning for teaching on their own is close to the actual planning situation they face in the future as teachers, the relationships found in this situation are of considerable importance. As the Solo score is an important indicator of the degree of development and quality of knowledge, student teachers in this study were expected to use knowledge at a high SOLO taxonomic level in planning for their teaching. The use of this kind of knowledge at an appropriately high level would help them fulfil their teaching tasks effectively (Biggs & Moore, 1993; Bransford, Brown & Cocking, 1999). Teacher educators often believe that in order to satisfy this expectation, students should equip themselves with knowledge that is rich in ideas and better developed. However, the results in this study reveal that the possession of rich and higher level knowledge is not enough to guarantee its usage for teaching, at least in this sample of teacher-education students. The current results suggest that these novice teachers gained considerable benefit from external prompting in the use of their knowledge. As the participants in this study were student teachers, further research should be conducted to investigate if the results here are applicable to novice teachers in schools. If this pattern of findings were replicated it would point to a need to develop systems of prompting for use of pedagogical knowledge for new teachers. Some form of external guidance should be provided for both student teachers in their teaching practice and for novice teachers in their actual teaching.

Methodologically, the descriptive analysis is important but it is not enough for the researcher to portray how students used their knowledge for planning questions for teaching in unprompted and prompted situations. The causal analysis in this paper gives a clear picture of how different features of the knowledge students held influence the knowledge that they use.

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